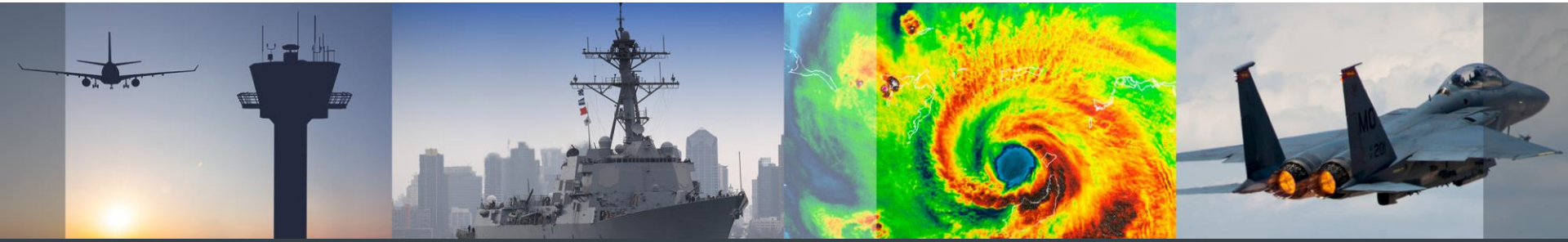
Communications & Power Industries



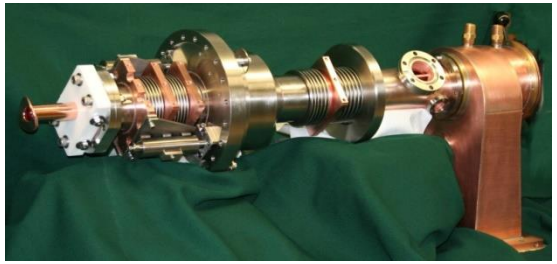
BEVERLY MICROWAVE

Power Couplers – Technology, Manufacturing, And Four Ways To Procure For Half The Price

Agenda

- Power Coupler Configuration Overview
- Power Coupler Manufacturing Technology
- Typical Cost Breakdown
- Four ways To Procure For Half the Price
- Open Discussion

Power Coupler Configuration Overview

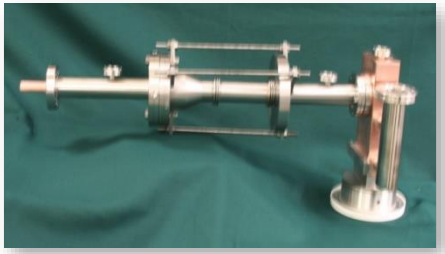






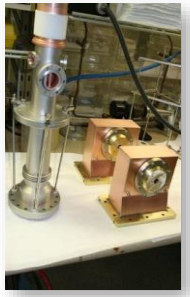






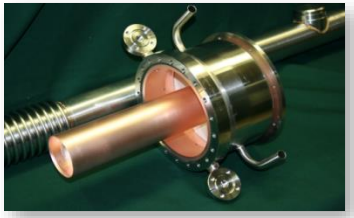
Power Coupler Configuration Overview



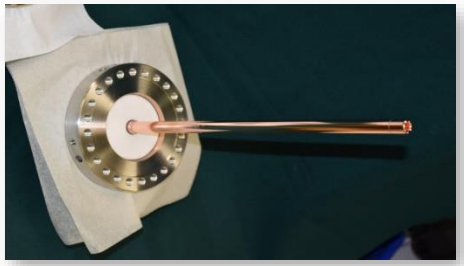




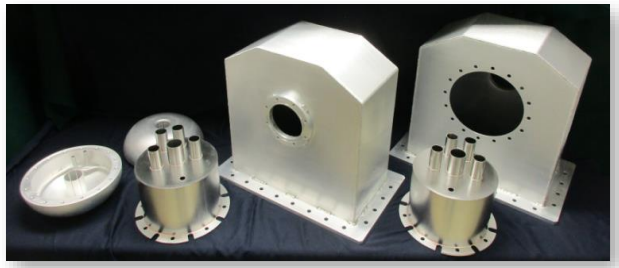


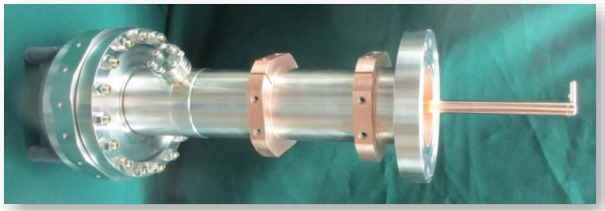


Power Coupler Configuration Overview

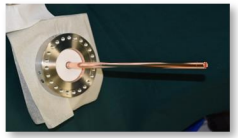





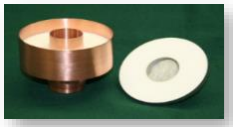


Power Coupler Manufacturing Technology



- High RRR copper plating
- UHV chemical cleaning
- Electro-polishing



- Ceramic to Metal Seals

- ISO Class 10/1000 clean room
- Bake-out Processing
- RGA Test

- Clean Room Assembly & QC

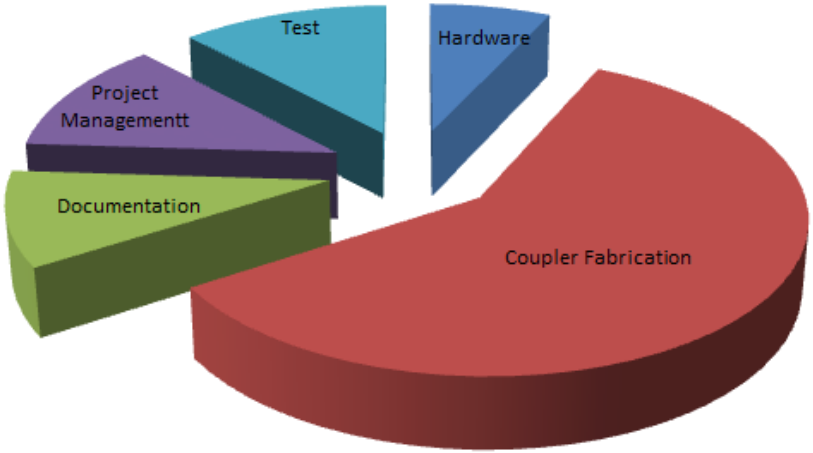
- UHV Vacuum and Hydrogen Brazing
- EB Welding, TIG Welding, Laser welding

- Titanium & Titanium Nitride Coating

Typical Cost Breakdown

Project Task — Percent Contribution

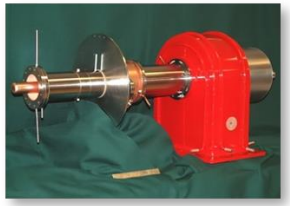
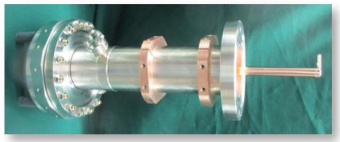
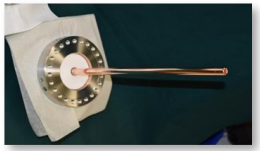
- Power Coupler Manufacturing Costs: -------- 50% -100%
- Power Coupler Clean Room Processing:------ 5% - 15%
  - Ultrasonic Clean
  - Bake-out
  - Packaging
  - Test (RGA, Particle Count, etc.)
- Testing:---------- 5% - 30%
  - Leak Check - Outgas rate
  - Process Control Tests (TiN, RRR Copper)
  - Fluid flow, Pressure Tests, LN2 shock
  - QC mechanical & Visual Inspection
- Project Management and Oversight:---------- 5% - 20%
  - Meetings, Documentation Generation
  - Customer Inspection Holds
  - Data Reviews & Reporting Functions
- Miscellaneous Hardware
  - Nuts&Bolts, Seals, Support Hardware:--0% - 15%



Four Ways to Procure For Half The Price –
- #1 Consider using a Single Window

- Consider designing coupler with a single window as opposed to double windows
- Single window designs can be as little as half the price of a double window design

Single Window Couplers

Double Window Couplers

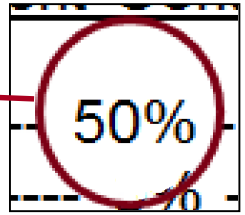


Four Ways to Procure for Half the Price – - #2 Minimize Coupler Specifications

- Consider minimizing specifications: Coupler contracts with the bare minimum test, cleanroom, hardware and oversight specifications can cost half of that of a loaded specification

Typical Cost Breakdown

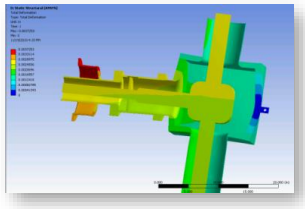
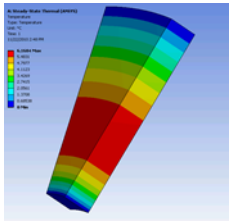
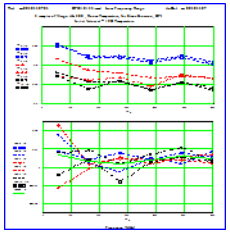
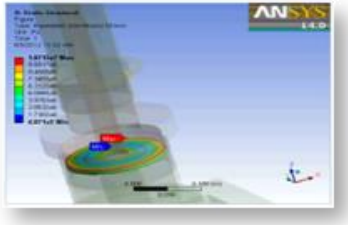
Project Task	Percent Contribution
- Power Coupler Manufacturing Costs:	50% - 100%
- Power Coupler Clean Room Processing:	5% - 15%
- Ultrasonic Clean	
- Bake-out	
- Packaging	
- Test (RGA, Particle Count, etc.)	
- Testing:	5% - 30%
- Leak Check - Outgas rate	
- Process Control Tests (TiN, RRR Copper)	
- Fluid flow & Pressure Tests	
- QC mechanical & Visual Inspection	
- Project Management and Oversight:	5% - 20%
- Meetings, Documentation Generation	
- Customer Inspection Holds	
- Data Reviews & Reporting Functions	
- Miscellaneous Hardware	
- Nuts&Bolts, Seals, Support Hardware:	0% - 15%

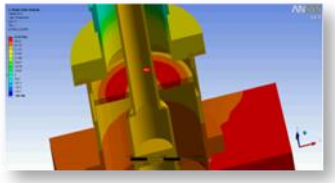
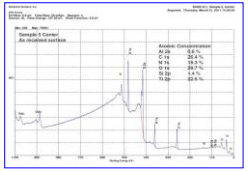
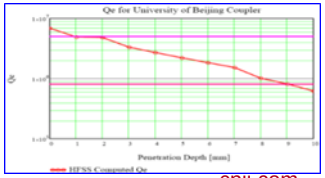


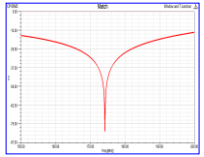
Four Ways to Procure for Half the Price –
- #3 Modify an Existing Design For Your Needs

- Modifying an existing design can decrease costs substantially as compared to complete new designs
  - Choose a design that has been built in high quantity that has already bared the “learning curve” costs
- Proven and tested designs may also offer less design risk and lower procurement times
- Modifying an existing design may take less time to design than starting from a blank sheet of paper
- This is a proven method that we and others have used successfully
- Finite element modeling and other tools makes design changes efficient to analyze and document
- Licensing agreements are offered by many national labs at reasonable rates.



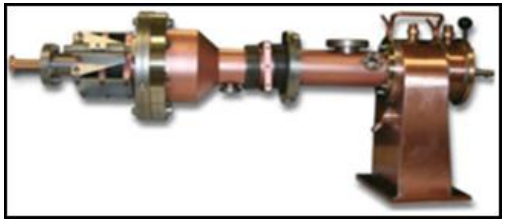







Four Ways to Procure for Half the Price –
- #4 Minimize Coupler Size if Possible

- Coupler size is a cost driver
- A coupler twice the length & diameter is a least twice the cost to produce
- For a Coupler at double the size:
  - Material prices may double
  - Labor and fixturing increase at about 50% -100%
  - Process capacity for brazing, TiN coating, plating, etc. decrease by 2 to 4 times
- Design larger and longer components only when driven by design requirements



Recommendations to reduce procurement costs

- Test sample requirements can represent 2 to 20% of program costs
  - Consider eliminating this requirement based on a vendor recently meeting similar requirements for a different customer
  - Consider eliminating this requirement if a vendor has had continuous Coupler production with other customers for a long period of time
- The use of ISO2768m for default tolerancing can cause acceptance issues if used together for piece parts and assemblies
  - Example: Three 6mm piece parts each carry a +/- 0.1mm tolerance. If stacked together the innate maximum tolerance is +/-0.3mm, yet the standard tolerance for the assembly using ISO 2768m is still just +/- 0.1mm
- Bake-out may represent as much as 15% of project costs
  - If the assembly was fired at 1000^{o}C in a vacuum furnace, it has already been baked-out to some extent

Recommendations to reduce procurement costs

- An outgas rate test may represent 1% to 6% of project costs
  - If the assembly was brazed in a vacuum furnace at 1000C using known low vapor pressure materials, it has already been qualified to some extent.
- Use vendors ISO9000/AS9001 program management system to eliminate redundant requirements
- Place tighter tolerances on piece parts to achieve final dimensional stack-up requirements, so that assemblies meet specification without the need for complex fixturing or final machining
- Specify the choice of ceramic material(s) instead of specifying properties of loss tan, density, dielectric constant, etc.
  - Otherwise vendor needs to qualify ceramic through an expensive series of tests

Open Discussion

- Open Discussion